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Cooking effects on bioactive compounds and sensory acceptability in pumpkin (*Cucurbita moschata* cv. Leite)[1]

Efeitos da cocção nos compostos bioativos e aceitação sensorial em abóbora (*Cucurbita moschata* cv. Leite)

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ABSTRACT - The present study aimed to compare the changes in the bioactive compounds, color parameters and to determine consumer opinions through sensory analysis of the pumpkin using different cooking methods (boiling, steaming, microwaving and sous vide). The cooking methods reduced the ascorbic acid content (49.73-50.42%) and polyphenols (49.68-64.94%). Microwaving increased the carotenoid content by 24.58%. The brightness (L^*), red color (a^*) and yellow color (b^*) were reduced and there was also the loss of vivid color (chroma). The color of samples was affected after cooking process. All cooking methods were well accepted by the tasters, representing different market niches and many consumers expressed the intention of purchasing these products. The main component analysis also indicated the acceptance of different treatments for three distinct groups of assessors, one formed by boiling and steam treatments and two others formed by sous vide and microwave alone. Pumpkins contain high levels of functional components, and microwaving is the preferred cooking method to promote their retention, which can be performed with enough guarantees that the product will always be purchased by consumers.

Key words: *Curcubita moscata*. Total polyphenols. Carotenoids. Sensorial acceptance. Gastronomy.

RESUMO - Este estudo teve como objetivos comparar as alterações nos compostos bioativos, parâmetros de cor e determinar as opiniões dos consumidores através da análise sensorial de abóbora preparada por diferentes métodos de cocção (ebulição, vapor, micro-ondas e sous vide). Os métodos de cocção reduziram o teor de ácido ascórbico (49,73-50,42%) e polifenóis (49,68-64,94%). A cocção em micro-ondas aumentou o conteúdo de carotenóides em 24,58%. A cor das amostras cozidas foi afetada, brilho (L^*), cor vermelha (a^*) e cor amarela (b^*) foram reduzidas e houve também perda de cores vivas (chroma). Os métodos de cocção foram bem aceitos pelos provadores, representando diferentes nichos de mercado e muitos consumidores expressaram a intenção de comprar estes produtos. A análise de componentes principais indicou também a aceitação de diferentes tratamentos por três grupos distintos de avaliadores, um formado pelos tratamentos ebulição e vapor, e outros dois formados por sous vide e micro-ondas individualmente. Abóboras contêm altos níveis de componentes funcionais, e cocção em micro-ondas é o método preferido para promover a sua retenção, a qual pode ser realizada com garantias suficientes de que o produto irá ser sempre adquirido pelos consumidores.

Palavras-chave: Ácido ascórbico. Polifenóis totais. Carotenóides. Aceitação sensorial. Mapa de preferência interno.

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INTRODUCTION

The regular consumption of fruit and vegetables is recommended in practically all dietary guidelines in order to maintain a balanced diet and to prevent obesity and chronic diseases (BLANCHFLOWER; OSWALD; STEWART-BROWN, 2013). A major benefit from a higher intake of fruits and vegetables may be the increased consumption of vitamins, minerals and dietary fiber (GÜLÇIN, 2012).

Pumpkin (*Cucurbita moschata*) is native from tropical and subtropical America, consisting of a succulent stem with numerous seeds and being one of the most important species of pumpkin in traditional agricultural systems in the world. This vegetable also has functionalities investigated in human health such as antioxidant, anti-carcinogenic, anti-inflammatory and antidiabetic (ADAMS *et al*., 2011). The medicinal properties of pumpkin are associated with its phenolic compounds content such as flavonoids. Besides that, the nutritional composition of pumpkin reveals the presence of vitamins, amino acids, carbohydrates, minerals, low energy content (RAKCEJEVA *et al*., 2011) and it is an excellent source of provitamin A (RIBEIRO *et al*., 2015).

Cooking promote chemical reactions in order to obtain a safe and high-quality food products being an essential condition to improve digestibility. However, this method can affect the texture and nutritional value of vegetables. This can be attributed to oxidation and the leaching or thermal degradation of chemical components, resulting in dilution of bioactive compounds (VEDA; PLATEL; SRINIVASAN, 2010). Cooking methods can also change the perception of consumers toward products of the same cultivar and farming system.

The comparison of influence of cooking methods on nutrients retention and phytochemicals help the catering and food service industries, as well as the individual consumer to select the most suitable cooking method for pumpkin. Thus, this study aimed to compare the changes in color parameters, bioactive compounds content and to determine consumer opinions through sensory analysis of pumpkin prepared using different cooking methods (boiling, steaming, microwaving and sous vide).

MATERIALS AND METHODS

Sample preparation and cooking procedures

Fresh pumpkin (*Cucurbita moschata* cv. Leite) in commercial maturity was obtained from Central Supply of Ceara S/A (Fortaleza, CE, Brazil). The pumpkins were carefully washed with tap water and then disinfected by immersion in water with 100 mg L^{-1} of sodium hypochlorite for 15 min, manually peeled and cut with stainless steel knives into 3 cm cubes and divided into portions (500 g each). One portion was retained uncooked while others were cooked with the addition of 0.2% of salt (sodium chloride), using different cooking methods (boiling, steaming, microwaving and sous vide). The portions were cooked with three different methods in a microwave oven (2450 MHz, 10 min), boiled in water for 8 min, and steamed in a steamer (95 ºC, 12 min). The samples were evacuated in vacuum bags by sous vide method (OPA/PP 15/65, Orved, Musile di Piave, Italy) with a VM-16 vacuum sealer (Orved) and cooked for 30 min in a water bath with a pump for circulating water at 90 ºC. For the analysis of color and bioactive compounds, the pieces were blended to a fine pulp for 5 min, using a mixer.

Bioactive compounds

The Ascorbic acid content was determined using the 2.6-dichlorophenol-indophenol 0.02% titration method, described by Zenebon, Pascuet and Tiglea (2008). Samples (5 g) were diluted with 100 mL of a 0.5% oxalic acid aqueous solution and at 5 mL of this dilution distilled water was added to make up a final volume of 50 mL. The solution was titrated by adding the 2.6-dichlorophenol-indophenol solution until a distinct pink-rose color was obtained. Several precautions were taken to avoid the loss of ascorbic acid, such as the use of reduced light and temperature of 4 ºC. L-ascorbic acid was used to prepare a standard solution (0.05 mg mL^{-1}) and the concentration was calculated by comparison with the standard and results were expressed as mg 100 g^{-1} fresh weight.

The yellow flavonoids and anthocyanins were extracted from 1 g of sample, with 30 mL of 95% ethanol/1.5 M HCl (85:15, v:v). The extract was transferred to a 50 mL volumetric flask, and the volume was completed with ethanol – HCl (1.5 M) and stored for 12 hours at 4 ºC (FRANCIS, 1982). After filtration, the absorbance was measured with a spectrophotometer (UV-1800; Shimadzu, Japan) at 374 nm to yellow flavonoids and at 535 nm to total anthocyanin. Results were expressed as mg 100 g^{-1} fresh weight.

The carotenoids were determined according to the method of Rodriguez-Amaya and Kimura (2004), adapted according samples weight, solvent and reagent volumes and the number of times extraction to obtain a colorless appearance of the residue. The extraction was performed with acetone (previously refrigerated for 2 hours) in the presence of celite (Hiflosupercel), using a pestle and mortar until the residue became colorless, and after that, the extract was partitioned with petroleum ether. After phase separation, the organic phase (petroleum ether) was filtered through anhydrous sodium sulfate to a 50 mL flask. The absorbance of the final material was obtained in a spectrophotometer (UV-1800; Shimadzu, Japan) at 450 nm. Results were expressed as mg 100 g^{-1} fresh weight.

Total polyphenols were determined by means of the Folin-Ciocalteu's reagent (LARRAURI; RUPÉREZ; SAURA-CALIXTO, 1997). Fresh and cooked samples from the pretesting stage were weighed (20 g) in centrifuge tubes and extracted sequentially with 20 mL ethanol/water (50:50, v:v) at room temperature (25 ºC) for 60 min. The tubes were centrifuged at 1,509.30 g for 15 min and the supernatant was recovered. Then 20 mL acetone/water (70:30, v:v) was added to the residue at room temperature (25 ºC), extracted for 60 min and centrifuged. Ethanol and acetone extracts were combined, made up to 50 mL with distilled water and used to determine polyphenol contents. Extracts (1.0 mL) or gallic acid standard solutions were mixed with 1 mL Folin-Ciocalteu reagent (1:3 in water), 2 mL 20% sodium carbonate solution and 2 mL distilled water. After standing for 30 min at room temperature (25 ºC), the absorbance was measured at 700 nm using a spectrophotometer (UV-1800; Shimadzu, Japan). Results were expressed as mg gallic acid equivalent (GAE) 100 g^{-1} fresh weight.

Color analysis

Soluble brown pigments were determined according to Rattanathanalerk, Chiewchan and Srichumpoung (2005). Samples were centrifuged at 1,509.30 g for 10 min, yielding 5 mL of supernatant, to which was added 5 mL of ethanol and it was centrifuged again, and then the supernatant was separated. The reading was performed in a spectrophotometer (UV-1800, Shimadzu, Japan) at 420 nm. A colorimeter (Chroma Meter CR-400; Konica Minolta, USA) was used to define the color of pumpkin by measuring L^*, $a^*$and b^* color space, chroma and hue angle. In this color space, L^* is the lightness which ranges from 0 to 100 and chromatic components of a^* (from green to red) and b^* (from blue to yellow) range from −60 to 60, chroma $[(a^2 + b^2)^{0.5}]$ and hue angle (arctan b/a). Prior to use, the Chroma Meter was calibrated against a standard white plate.

Sensory evaluation

The acceptability test was carried out using a group of non-trained panelists (n = 50), being 90% of the female tasters, with ages ranged from 18 to 50. More than 70% of these between 18 to 25 years, and 70% of them undergraduate students. The test was also carried out using and a nine-point structured hedonic scale (1 - extremely dislike; 9 - extremely like) (MEILGAARD; CIVILLE; CARR, 2015), for the following attributes: color, appearance, flavor, texture, and overall acceptability. About 25-35 g of each sample was monadically presented, using white light and conventional temperature presentation, in white plastic containers coded with random three-digit numbers.

Statistical analysis

The experiment was conducted in a completely randomized design with three replications of each of the four cooking methods. The data was subjected to variance (ANOVA) analysis at 5% probability by the F-test ($p \leq 0.05$) and Tukey's multiple-comparison test ($p \leq 0.05$), using SAS software, version 9.4. The acceptability data was evaluated by the internal preference map methodology, using the principal component analyses (PCA) technique and XLSTAT software, version 5.01.

RESULTS AND DISCUSSION

Effect of cooking on bioactive compounds

There was significant variation in the parameters of total carotenoids and polyphenols of the samples obtained through different cooking methods (Table 1).

Table 1 - Bioactive compounds (mg 100 g^{-1} fresh weight), color indices and sensory acceptance of fresh and cooked pumpkin

Determinations	Treatments				
	Raw	Boiling	Steaming	Microwaving	Sous vide
Ascorbic acid	14.38 ± 0.12 a	7.18 ± 0.04 b	7.19 ± 0.02 b	7.23 ± 0.05 b	7.13 ± 0.04 b
Yellow flavonoids	13.36 ± 0.62 a	11.40 ± 0.34 b	10.95 ± 0.48 bc	13.73 ± 0.20 a	9.31 ± 0.34 c
Total anthocyanins	1.63 ± 0.19 a	1.22 ± 0.08 b	1.04 ± 0.08 b	1.60 ± 0.27 a	0.74 ± 0.08 c
Total carotenoids	19.89 ± 0.30 bc	20.34 ± 0.13 b	18.74 ± 0.05 c	24.77 ± 0.09 a	8.93 ± 0.38 d
Total polyphenols (GAE)	60.12 ± 2.58 a	21.08 ± 3.08 d	27.04 ± 1.03 bc	24.30 ± 1.94 cd	30.25 ± 3.64 b

*Means and standard deviations of triplicate analyses; Values followed by at least one different superscript letter in the same line are significantly different ($p \leq 0.05$) according to Tukey's test; GAE: Galic acid equivalent

All of the four cooking methods caused losses of around 50% for ascorbic acid when compared to uncooked samples. Pellegrini *et al.* (2010) found reductions in levels of ascorbic acid in cauliflower by boiling for 10 min, 42.1%, steaming for 11 min, 32.2%, and microwaving for 30 min, 94.7%. Vitamin C is sensitive to the action of heat and exposure to oxygen and light, that makes difficult its retention during cooking. In addition, vitamin C may be degraded by the presence of metal catalysts, alkalis, injury and low humidity (GIANNAKOUROU; TAOUKIS, 2003), and leaching is the main reason for the high losses of ascorbic acid during cooking (BERNHARDT; SCHLICH, 2006). However, the amount of ascorbic acid observed in this study for the pumpkin obtained through boiling 7.18 ± 0.04 mg 100 g^{-1} was greater than that reported by the United States Department of Agriculture - USDA database (2018). In this case, the study reported a value of 4.7 mg 100 $g^{-1.}$ Despite the low ascorbic acid content found in the different samples, 100 g of cooked pumpkin in a microwave oven can contribute to 16.1% of the recommended daily intake (IDR) by FDA/USDA for adults of this vitamin which is 45 mg 100 g^{-1}.

The yellow flavonoids values showed significant differences ($p \leq 0.05$) between the samples obtained by microwaving and the *sous vide* samples and by the other cooking methods in this study, while samples obtained by boiling and steaming did not differ ($p > 0.05$) in the content of these flavonoids.

The cooking methods used caused losses in total anthocyanins, revealing a significant difference ($p \leq 0.05$) between the cooking method in microwave and other cooking methods performed. The samples which had been microwaved had the highest amount of anthocyanins, whereas the *sous vide* samples had the most reduced value (54.37%), and the heating time of 30 min can be identified as a major cause of degradation of anthocyanins.

Cooking sous vide affected yellow flavonoids the most (30.27%), probably due to longer exposure to the heat treatment and light penetration in the package. However, disregarding the fresh sample standard deviation, microwaving virtually no loss occurred on flavonoids content. Pellegrini *et al*. (2010) observed that boiling for 8 min caused a negative effect on the content of flavonoids in broccoli, causing a loss of 50%. Rodrigues *et al*. (2009), in research with onions, found that the greatest loss of flavonoids occurred during boiling due to the migration of these compounds into the cooking water.

Rodrigues *et al.* (2009), evaluating the effect of cooking on anthocyanin varieties of onion bulbs, realized that in the samples obtained by gentle boiling, there was no degradation but a transfer to the boiling water took place: by 50% for the malonyl forms and by 20–30% for the non-acylated ones. The stability of the color of anthocyanins is dependent on the structure and concentration of pigments, as well as factors such as pH, copigmentation, light, temperature, metals, oxygen, factors that should be monitored after processing to ensure better conservation of the sensory aspect of products (LOPES *et al*., 2007). Anthocyanin degradation usually follows the first-order kinetics, i.e., anthocyanin content exponentially decreases with time (TONON; BRABET; HUBINGER, 2010).

The sous vide method caused more losses on total carotenoids, about 50% of its content, which can be attributed to some factors degrading during processing such as light and exposure time to heat treatment. However, microwaving allowed greater availability of this important compound when compared to uncooked samples. This fact which can be explained by an easier extraction in the sample processed by the heat treatment also inactivates oxidative enzymes and denatures the carotenoid-protein complexes which exist in vegetable cells (CAMPOS; ROSADO, 2005). The impact of cooking on many other vegetables also produced different results. Carotenoids are found primarily in the *trans* form, which is more stable, but the presence of some physical factors and/or chemicals such as direct sunlight, pro-oxidants and heat may cause a change in the molecule. The thermal degradation of β-carotene with an increase in temperature was due to oxidative and non-oxidative changes such as *cis–trans* isomerization and epoxide formation (DUTTA *et al.*, 2006) reducing its biological activity. Rodriguez-Amaya, Kimura and Amaya-Farfan (2008) considers that foods containing more than 2.00 mg 100 g^{-1} of carotenoids are important for health.

After cooking procedures, the total polyphenols content of the pumpkin was significantly ($p \leq 0.05$) reduced from 49.68 to 64.94% in all cooking methods. The boiling and microwave methods contributed to the lower concentration of total polyphenols. The reduction in total polyphenols content after boiling or microwaving may be due to the breakdown of phenolics during cooking. In steaming, the lower temperature compared to the boiling point and microwaving, may explain the increased preservation of phenolic compounds. Turkmen, Sari and Velioglu (2005) obtained a reduction of 40%, 30% and 33% in phenolic compounds of the pumpkin after cooking procedures through boiling for 5 min, steaming for 7.5 min and microwaving for 1 min, respectively. In vegetables, phenolic compounds occur in soluble forms in combination with cell wall components. The losses of phenolics can be by leaching at high temperatures and long times, responsible for the disruption of the cell walls and the degradation (FRANCISCO *et al.*, 2010). According to these authors, after cooking, total phenolics content in turnip greens was reduced in 15%, steaming, and 72%, conventional boiling.

Variability of the impact of cooking on phytochemical content may be related to the type of commodity and genotype, growing location, specific compound assessed, the matrix to which the compound is bound (fats, proteins, carbohydrates, or starches), the amount of physical processing of the fruit or vegetable before cooking, the conditions of the cooking process (including heat-transfer method, time, and amount of water added), and method of compound quantification (BLESSINGTON *et al*., 2010).

Effect of cooking on color parameters

Soluble brown pigments were significantly ($p \leq 0.05$) affected by all the cooking methods used (Table 2). However, there was a greater increase in the value determined for the soluble brown pigments of the pumpkin obtained through the sous vide cooking method. This was expected since the sous vide samples were exposed to heat treatment for a longer period compared to the other cooking methods and preservatives and browning inhibitors were not added, which may have favored the occurrence of enzymatic and non-enzymatic browning. The clearest evidence that food has suffered some reaction is browning and Maillard reaction wich are the most common cause of such behavior in cooked vegetables.

Cooking of fresh pumpkin induced a significant L^* decrease for all cooked products. Loss of redness (a^*) were more significantly ($p \leq 0.05$) shown in steamed and microwaved pumpkins. Hue angles remained substantially unvaried except for sous vide pumpkin, which showed a significant ($p \leq 0.05$) decrease of orange color, probably as a consequence of the redness decrease. Trejo Araya *et al.* (2009), analyzing carrots, showed that the samples which had been boiled had a larger hue angle, which represents an inclination to the color yellow. Chroma decreased significantly ($p \leq 0.05$) for all cooked products, indicating the reduction of characteristic color, however, remained substantially unvaried between the cooking methods used. The color of pumpkins was mainly related to carotenoid pigment content, which are the natural plant pigments responsible for the orange color of the pumpkin (AZIZAH *et al.*, 2009), which in turn are profoundly affected by variety, maturity and growth conditions. Therefore it is difficult to compare the color parameters obtained the data reported in the literature, due to the high variability of these vegetables. The index b^* was not affected by cooking methods.

Effect of cooking on sensory evaluation

In regard to the evaluation of color, the microwaved pumpkin received the highest average scores. However, there was no statistical difference ($p \geq 0.05$) among the samples, which had means between the hedonic terms “like very much” and “like moderately” (Figure 1). Pellegrini *et al*. (2010) found that microwaving was the best method of cooking to retain the color of broccoli, cauliflower and Brussels sprouts, compared with boiling and steaming. The color is one of the most important attributes of foods, being considered a quality indicator and frequently determining their acceptance.

Regarding the appearance, the samples presented no statistical differences ($p > 0.05$), being on the same track on the hedonic scale, between the terms “like very much” and “like moderately”. The appearance is the most important quality considered by consumers when buying a product (JAEGER *et al*., 2018; MUGGE; DAHL; SCHOORMANS, 2018). Trejo Araya *et al.* (2009), analyzing sous vide carrots and boiled carrots, obtained the highest score appearance of orange color intensity in the sous vide samples and a less intense orange color, almost fluorescent, but bright in the boiled samples.

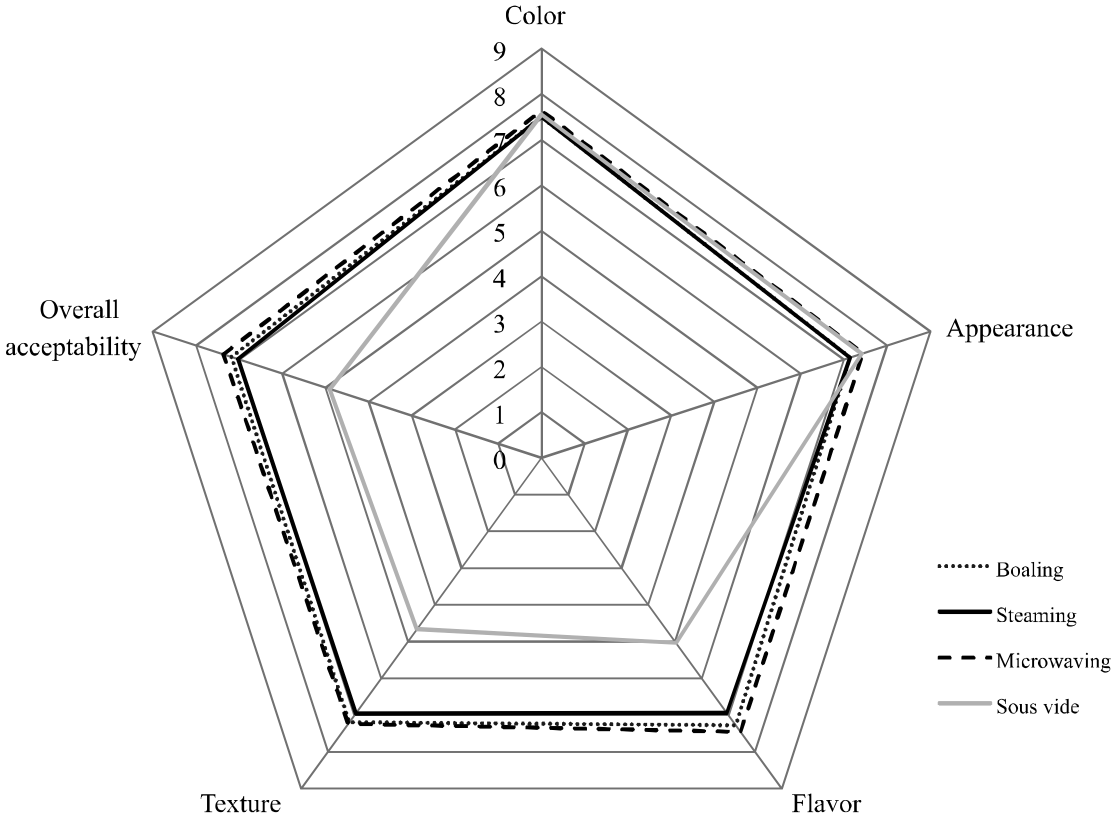
The results indicated significant differences ($p \leq 0.05$) in regard to flavor in sous vide compared to the other cooking methods, being in the hedonic scale range

Table 2 - Color indices of fresh and cooked pumpkin

Determinations	Treatments				
	Raw	Boiling	Steaming	Microwaving	Sous vide
Soluble brown pigments	0.25 ± 0.02 b	0.15 ± 0.03 c	0.18 ± 0.02 c	0.18 ± 0.01 c	0.31 ± 0.04 a
L*	43.39 ± 1.66 a	39.23 ± 0.76 b	37.45 ± 1.44 b	38.22 ± 0.40 b	37.37 ± 2.63 b
a*	7.34 ± 1.26 a	5.16 ± 0.79 ab	4.66 ± 1.12 b	4.60 ± 0.79 b	6.30 ± 1.68 ab
b*	11.92 ± 0.43 a	11.85 ± 1.47 a	11.44 ± 1.72 a	11.30 ± 1.21 a	11.35 ± 2.46 a
Chroma	20.66 ± 1.25 a	12.96 ± 1.69 b	12.38 ± 2.76 b	12.16 ± 1.56 b	12.85 ± 2.74 b
Hue angle	66.01 ± 0.17 a	66.55 ± 0.82 a	68.07 ± 1.63 a	68.32 ± 1.95 a	60.82 ± 4.62 b

*Means and standard deviations of triplicate analyses; Values followed by at least one different superscript letter in the same line are significantly different ($p \leq 0.05$) according to Tukey’s test

Figure 1 - Sensory acceptability of pumpkin obtained by different cooking methods (Nine-point structured hedonic scale: 1 - extremely dislike; 9 - extremely like)



between "like slightly" and "neither like nor dislike". The microwaved pumpkin had the highest mean value, followed by the boiled and both had an average between the hedonic terms "like very much" and "like moderately" while the steamed pumpkin was between the hedonic terms "like moderately" and "like slightly". Pumpkins prepared in steamed and sous vide showed less preference possibly due to more intense flavor (preservation of volatiles). Trejo Araya *et al.* (2009) found that carrots cooked through boiling had the highest intensity of "processed flavor", followed by the sous vide sample.

According to the considerations made by the panelists about what else they liked or disliked in the tested samples, the low acceptance of the flavor of samples cooked in sous vide seems to be due to the fact that they present a strange flavor (like a raw vegetable) to consumers (ROASCIO-ALBISTUR; GÁMBARO, 2018; RONDANELLI *et al.*, 2017). Treatment in a microwave masked the taste of raw pumpkin and gave a sweet taste, which usually caused a pleasant feeling to the tasters and the steam treatment conferred a nondescript taste to the product, which seemed to displease most tasters.

Regarding texture, the sous vide pumpkin was statistically different from the others treatments, presenting hedonic value between the terms "neither like nor dislike" and "dislike slightly" while the texture of the microwaved was the one that most pleased tasters, getting evaluations between the hedonic terms "like very much" and "like moderately". Steamed had an average between "like moderately" and "like slightly". These parameters may be related to different times and temperatures used during the different cooking methods performed. In a sensory evaluation study with cooked potatoes García-Segovia, Andrés-Bello and Martínez-Monzó (2008) suggested that the binomial time-temperature exerts a major influence on the textural parameters. Aboubakar *et al*. (2009) revealed that during the cooking of taro corms the physicochemical properties and texture varied with the time and cooking method. The steam cooking of the slices induced the highest softening while boiling in water induces the lowest softening of the corms. According to Trejo Araya *et al*. (2009) the textures of the carrots obtained by sous vide was less crunchy than the raw carrots which cooked in boiling water were perceived as very low in terms of crunchiness. The sample obtained through sous vide was more fibrous than the sample obtained through boiling.

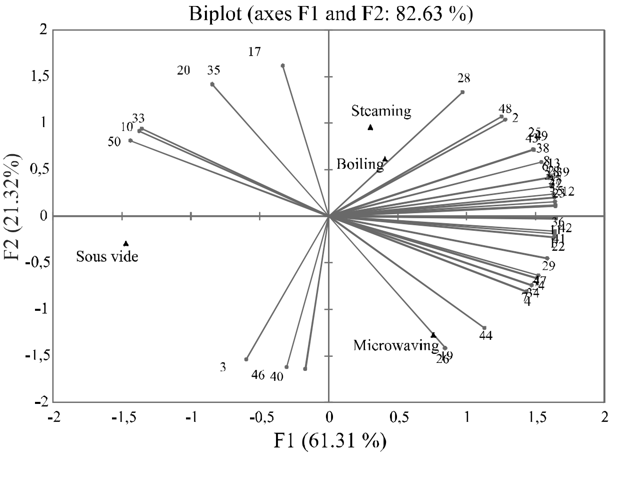
In the overall acceptability, the sous vide pumpkin presented averages close “neither like nor dislike”, differing from the other samples which showed averages between the attributes “liked very much” and “like moderately”. Rennie and Wise (2010) obtained answers ranging between “liked very much” and “like moderately” for all attributes for carrots cooked through boiling, steaming and microwaving.

Comparative evaluation of the four cooking methods evaluated demonstrated that the color was the sensory attribute most accepted between samples, revealing that the pumpkins obtained by microwaving achieved the greatest acceptance. However, the attributes such as color, appearance, flavor, texture and the overall acceptability of pumpkins obtained by boiling, steaming and microwaving were accepted by the criterion adopted, since over 50% of the tasters gave grades ≥ 6.

PCA to evaluate the data matrix acceptance with respect to the overall acceptability attribute can be seen in Figure 2.

The two main components represented 67.09% in the evaluation of the overall acceptability. The formation of three distinct groups could be observed, one formed by boiling and steaming methods in the first quadrant and two others formed through sous vide and microwaving individually in quadrants three and four, respectively. The study found that 20% of the tasters did not like any of the methods. Presentation of the test averages was confirmed, where steaming and boiling showed values close to the overall acceptability and a lower average value for sous vide. Therefore, there is the acceptance of different treatments for distinct groups of tasters.

Figure 2 - Internal preference map of hedonic ratings from 50 tasters for overall acceptability of pumpkins obtained by different cooking methods



CONCLUSIONS

1. The present study revealed the loss of bright colors for all cooked samples in regards to fresh pumpkins, and a reduction of ascorbic acid content and polyphenolic compounds also occurred. Microwaving treatment provided greater retention of carotenoids with a higher value than those found in fresh samples while steaming and sous vide treatments caused a reduction in these values. Pumpkin has proved to be an excellent source of carotenoids, which can be used to combat vitamin A deficiency because it is a vegetable that is affordable and easily processed;
2. PCA allowed the identification and characterization of the groups of consumers and their preferences. The sous vide cooking had lower averages for flavor, texture and overall acceptability. This result can be attributed to the greater cooking time compared to the other treatments, which conferred higher sensory changes to the product.

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